LUNAR TETHERED RESOURCE EXPLORER (Lunar T-REx).

T. J. Stubbs[1], M. E. Purucker[1], J. D. Hudeck[2], R. P. Hoyt[3], B. K. Malphrus[4], M. A. Mesarch[1], M. Bakhtiari-nejad[1], G. E. Cruz-Ortiz[1], E. T. Stoneking[1], T. E. Johnson[2], D. J. Chai[1], D. C. Folta[1], and R. R. Vondrak[1], [1]NASA Goddard Space Flight Center, [2]NASA Wallops Flight Facility, [3]Tethers Unlimited, Inc., [4]Morehead State University. Point of contact: Timothy.J.Stubbs@NASA.gov

Introduction: The Lunar Tethered Resource Explorer (Lunar T-REx) is a SmallSat mission concept that aims to significantly improve the characterization of crustal magnetic fields at the Moon, which would be highly enabling for both science and exploration activities. It would measure magnetic fields at very low lunar altitudes (<20 km) with the goals of: (i) determining the origin and depth of magnetized material, (ii) understanding the effect of impacts on crustal magnetism, tectonism and volcanism, and (iii) examining the role of crustal fields on interactions of the Moon with the space environment and the formation of bright swirl patterns. This is highly relevant to objectives identified in the Planetary Decadal Survey and SSERVI's Transformative Lunar Science recommendations, as well as Strategic Knowledge Gaps (SKGs).

Such measurements could also facilitate the search for resources during future exploration. On Earth, economically viable mineralization associated with large impact craters can often be identified by magnetic signatures observed close to the surface. On the Moon, many large Nectarian-aged impact features have prominent magnetic features associated with their central peak regions that may contain signatures of economic mineralization – if measured at very low altitudes.

Tethered Architecture: However, low altitude lunar orbits (<50 km) are very unstable, and without regular orbit maintenance maneuvers last only a few weeks or less. A mission surveying crustal fields would require at least a few months, if not longer, which requires a prohibitive fuel mass burden, especially for SmallSats.

Lunar T-REx would use two SmallSat/CubeSat buses connected by a tether (many kilometers long) that orbit in a vertically-aligned gravity gradient formation. The advantages of this architecture include very low altitude measurements from stable orbits providing long mission lifetimes.

Payload and Measurements: The primary payload would be mini-magnetometers deployed on stacer booms. The dual-point (high and low altitude) measurements would enable more accurate determination of crustal fields. Nadir-facing, mini-cameras would be included to image surface features for more accurate registration (lower spacecraft), and monitoring tether deployment and dynamics (upper spacecraft).

Leveraging: Lunar T-REx builds upon findings from the PSDS3/BOLAS mission concept study, which used two EPSA-class SmallSats connected by a 25 km tether with the formation center-of-mass in a "frozen" orbit that was stable for >1 year. The primary BOLAS target was the Gerasimovich crustal field region with its swirls. At closest approach, the lower spacecraft was only 2 km from the surface, and regularly surveyed Gerasimovich at altitudes <12 km.

BOLAS leveraged on-going experience from the EM-1 Lunar IceCube mission (PI Ben Malphrus), as well as heritage from tethered missions flown in LEO.

The BOLAS concept was shown to be feasible, with the next steps being: (i) maturation of the tether deployment system for a lunar application, (ii) assessment of tether survivability against dust impacts in lunar orbit, and (iii) development of an attitude control system (ACS) model that could account for tether forces.

These modest investments would advance the "game-changing" technology required for realizing tethered missions to the Moon with a wide variety of applications.